GBDSO

Gameboy Digital Sampling Oscilloscope (2)

Part 2: PC link, DSOGrab, construction and testing

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The PC Link Interface

Data may be transferred from the GB to a standard PC computer via a link lead, which connects the GB link port to the PC printer port. The associated software utility to run on the PC is called 'DSOGrab' and may be obtained on floppy disk (see Software Items inset). The GB link port is in fact a serial data port but unfortunately the data format is non-standard and therefore has to be read as a data stream by the PC and converted back into byte format. The connections of the GB link port are shown in **Figure 7**.

All outputs and inputs to the GB link port are TTL compatible and can be connected directly to the PC printer port. Extra care must be taken when wiring the link lead to make sure all the connections are correct as errors could cause permanent damage to the GB or PC ports. The loop-back connection between pins 4 and 11 is used to test if the software can see the connector and is used for fault diagnoses.

The GB link port contains an 8-bit shift register, which contains the current data byte to be sent or read. Clocking of this register can be done externally by pin 3 of the printer port. Initial synchronisation between the GB and PC is achieved when the PC reads an initiation byte from the serial port via pin 10. The PC will then write back to the GB via pin 2 and serial transfer commences. Two modes of transfer are possible:

Screen transfer where the entire screen is sent to the PC and saved in a .BMP format.

Data transfer where the actual data values of CHA/B are sent to the PC.

The raw data format is as follows:

600 bytes of CHA data, 600 bytes of CHB data.
CHA position, CHB position, CHA gain, CHB gain, TIMEBASE setting (1 byte each).

The CHA/B data values are the actual screen points and have a range between 7 and 127. The CHA/B position bytes are where the trace zero reference markers are on the screen, again between 7 and 127. The CHA/B gain values are between 0 and 9, with 0=OFF and 9=10V (see 'Standard Menus'). In FFT mode 0=OFF and 9=35dB (see 'Getting the most out of the FFT'). The TIMEBASE setting is between 2 and 26, with 2=5uS and 26=500S (see 'Standard Menus'). In FFT mode 2=100KHz and 12(max)=10Hz (see 'Getting the most out of the FFT').

When data is saved as MathCad 6.0 format, data and position values range between 0 and 127. The GAIN

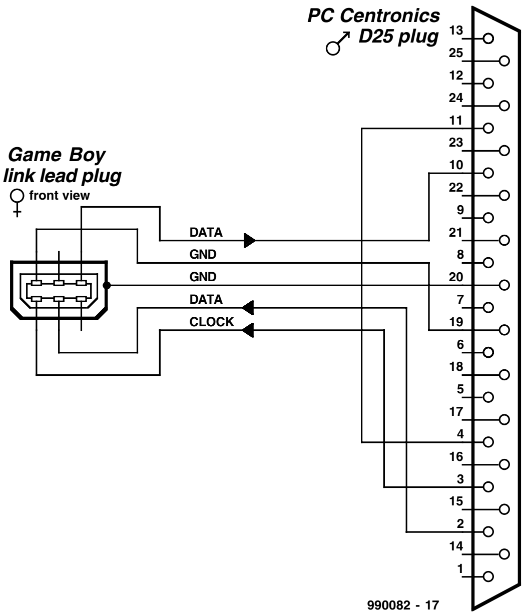

Figure 7. GB to PC link lead (view shows front of plugs).

and TIMEBASE values are converted to floating point values representing the actual scale settings. A MathCad demonstration file is included in the Windows 95/98 link software disk supplied for this project.

Assembly

Assembly will require a very steady hand and some practice if you have never soldered surface mount assembly (SMA) components before. Soldering will require a fine tip iron with a 1-mm tip, 26-gauge low melting point solder or solder paste and pair of fine tweezers. A solder wick is useful for removing excess solder, but do not use a solder sucker as this will probably break the PCB tracks. There are two methods of building the circuit, if you are competent at SMA handling then you skip the step by step approach below.

The following steps allow each semiconductor to be soldered and tested in turn to check for

COMPONENTS LIST

All components SMA (surface mount assembly)

Resistors:
SMD case 0805, 0.1 watt
R1,R2,R4,R8,R9,R11 = 1MΩ 1%
R15 = 15kΩ
R5,R12 = 470kΩ 1%
R3,R6,R7,R10,R13,R14 = 4kΩ7 1%
R16,R17 = 100kΩ 1%
P1,P2 = 100kΩ preset

Capacitors:
SMD case 0805
C1,C10 = 18pF NP0
C2,C4,C5,C8,C9,C11,C12,C14,C17-C21,C23,C27,C29,C30 = 100nF
C3,C13 = 1pF8 NP0
C6,C15 = 15pF NP0
C7,C16 = 220pF NP0

Electrolytic capacitors
SMD Case A
C22,C24,C25,C26,C28,C31,C33 = 10μF 16V

Inductors:
L1,L2,L3 = 100μH

Semiconductors:
D1,D2 = BAV199 (print on case: JY)
D3 = ZR25D01 (print on case: 25R)
IC1,IC3 = MC33182D (Motorola)
IC2 = DS1267S100 (Dallas Semiconductor)
IC4 = MAX114CAG (Maxim)
IC5 = 74HC175D
IC6 = 74HC138D
IC7 = AT27C256R-12JC in PLCC44 case (programmed, Publishers' order code **996528-1**) (Atmel)
IC8 = TLC27L2CD
IC9 = MAX828EUK (print on case: AABI) (Maxim)

Miscellaneous:
S1,S2 = ''Secme' slide switch, 1 changeover contact, PCB mount
K1,K2 = 3.5mm PCB mount stereo socket (make sure it fits the board)
PCB, Publishers' order code **990082-1**
Disk, Publishers' order code **996035-1**

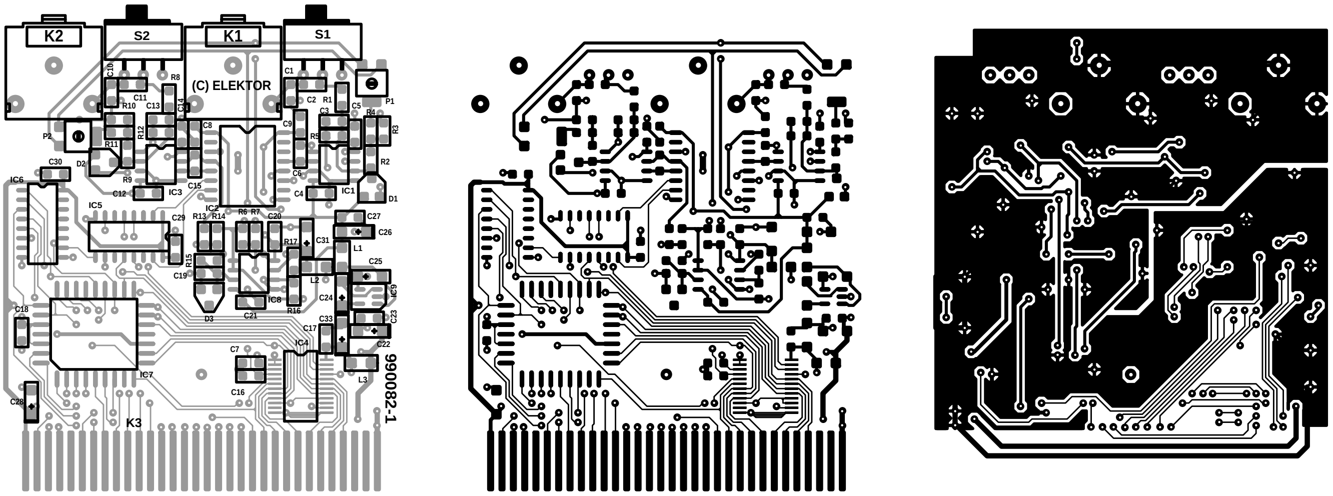

Figure 8. PCB design for the double-sided through-plated cartridge board.

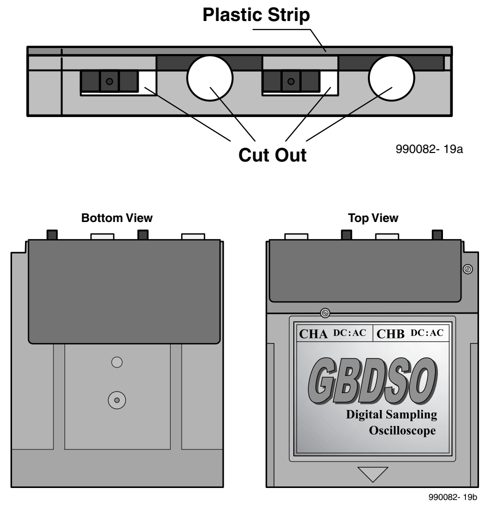

Figure 9. ROM case cut outs, and home made metal film.

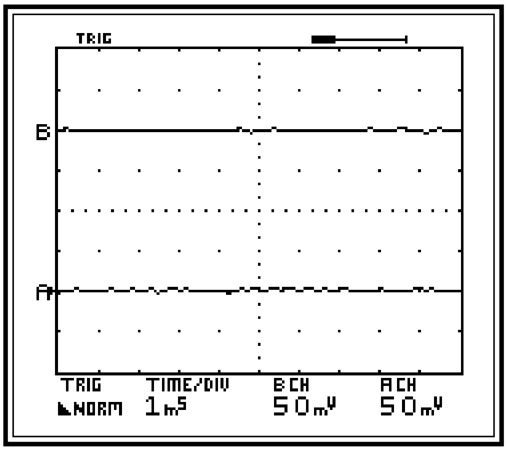

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Figure 10. Calibrating the 50 mV/DIV range on CHA and CHB

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short circuits during assembly.

1. Disassemble the plastic ROM case (see below) and place the PCB in the bottom. Carefully plug it into the GB. Switch on and check the black scrolling start screen appears. If not, there is a short on one of the GB interface tracks.
2. Solder the EPROM onto the PCB taking the usual static precautions. A good tip is to solder just two corner pins first and get the device aligned before soldering the rest of the pins. Place the PCB back into the case and switch on. The GBDSO intro screen should now appear and all the scope menus should work. If not, check for shorts.
3. Now solder the MAX114 ADC and 74HC138 and check that the unit still starts.
4. Finally solder the 74HC175 and DS1267 EPOT devices and capacitors C17, C30. Check the unit still starts. If not, check for shorts.

Start with the resistors and small capacitors, taking care not to short any tracks or touch the edge connector with solder. Some tracks run under components, and care should be taken not to short out these tracks. The inductors and tantalum capacitors are next, followed by the semiconductors. Note that the tantalum capacitors and semiconductors must be soldered the correct way around. Static precautions **must** be taken when soldering the sensitive input amplifiers IC1 and IC3. Finally, solder the jack sockets and AC/DC switches. It is advisable to cut the socket leads flush to the board before soldering and then gently file/sand the joints to be flat to the PCB.

The ROM cartridge is a standard case, which can be obtained from an old game. It is held together with one tamperproof screw that can be undone with a pair of fine nose pliers or cutters if the correct tool is not available. It is necessary to cut and file out the back of the bottom plastic case to accommodate the jack and AC/DC switches at the rear of the ROM cartridge — see Figure 9 and the photographs. The PCB should now fit snugly into the bottom of the case. Finally, the top case section must be cut to give enough clearance for the jack sockets. It is

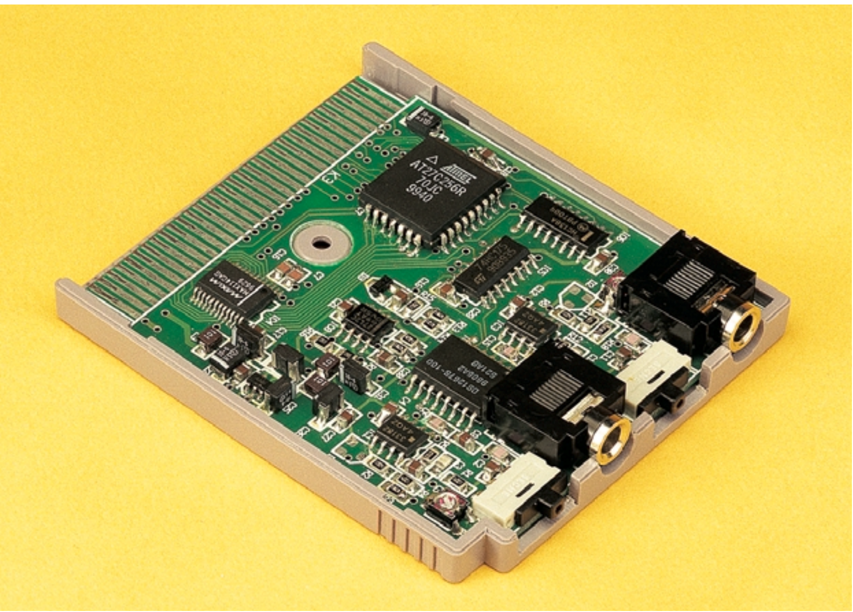

Figure 11. Completed cartridge board, ready for inserting into the Gameboy console.

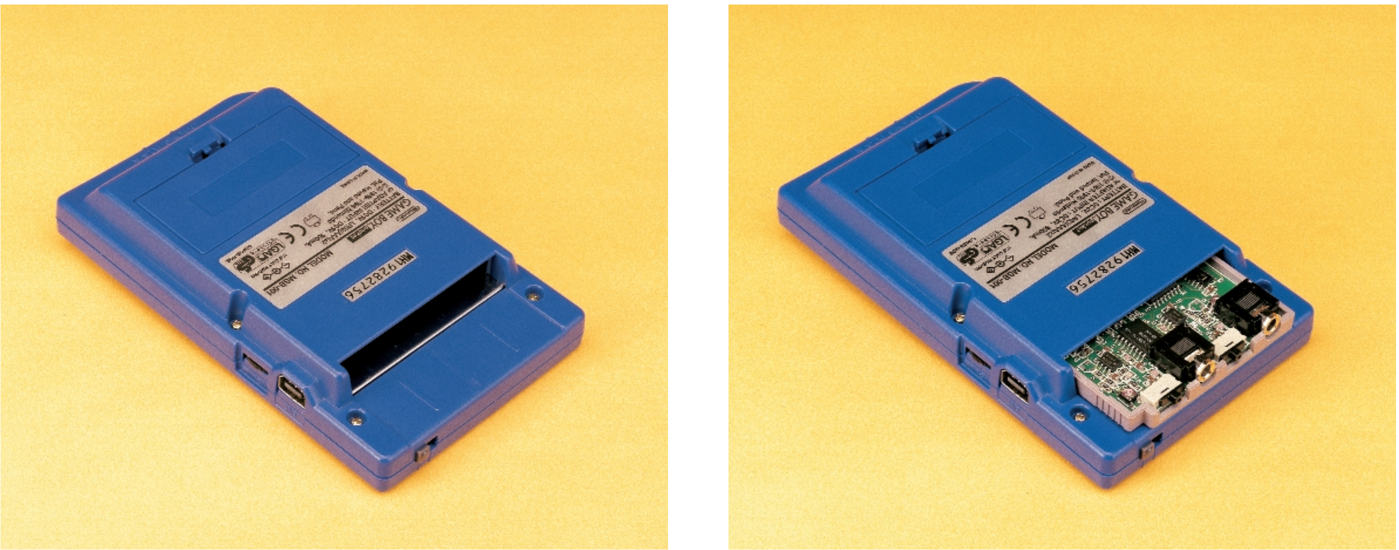

Figure 12. Rear view of Gameboy console with GBDSO cartridge removed (left) and installed (right).

advisable to stick a thin sheet of plastic (1×17×55mm) along the top of the cartridge for strengthening. To improve the GBDSO performance when measuring small signals, a thin sheet of metal (copper or aluminium) is bent around the case and stuck with double-sided tape. This is grounded by the jack plug nuts. This reduces interference caused by the LCD controller that can be picked up by the high impedance input amplifiers.

Test and calibration

To test the scope, switch on with no inputs applied and select dual-channel AC from the start screen. Set the AC/DC switches to DC (right), and both traces should appear in line with their respective A/B marker on the left-hand side. If not, adjust the DC zero level of the input amplifiers with the presets P1/2 so the traces are correctly aligned. If the traces are still not visible, check the DC voltages around the input amplifiers and ADC and compare these with the circuit diagram. Next increase the input sensitivity to 50 mV/DIV and adjust the presets again to finely calibrate the DC levels as shown in **Figure 10**. Set the sensitivity back to 1 V/DIV and apply a 1 kHz 1 V_{pk} sine wave to the either input channel and check that each trace responds to the signal. Next, apply a DC voltage to the inputs (e.g., 5 V regulator) and check the Y scale calibration. If you switch the inputs to AC then the traces should return to their zero position.

Scope probes

For normal operation, conventional scope probes with a 1:1 or 10:1 switch give ideal performance and extend the input voltage range by a factor of ten. The screen scale is calibrated for 10:1 probes (9 MΩ resistance) and one should remember to multiply the scale by a factor of ten when using 1:1 probes (0 MΩ resistance). Most commercial probes come with a BNC plug attached, which should be replaced with a mono 3.5-mm jack plug to connect to GBDSO. Care must be taken when selecting the probe to ensure that the compensation network is in the probe end and not the BNC connector. Often, soldering the inner wire is difficult and plated wire should be cleaned first.

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References:

1. Digital signal Processing – Ifeachor Jervis, ISBN 0-201-54413-X
2. Z80 Assembly Language Programming – L.A. Leventhal, ISBN 0-931988-21-7
3. Author's Gameboy web page: www-ev.phy.cam.ac.uk
4. Jeff Frohwein's Technical Page: www.devrs.com/gb/
5. Pascal Felber and Michael Hope's GBDK: http://gbdk.sourceforge.net/
6. Ian James GBDS: www.geocities.com/Eureka/9827/
7. Dr Pan's Gameboy technical documentation: www.gbdev.org/news/dl.html
8. Paul Robson's GB97 emulator: http://users.aol.com/autismuk/gameboy.htm

urls available as hyperlinks on the Hyperlinks page of the Elektor Electronics website.

Ready-Built GBDSO Cartridge Boards

Please check our website http://www.elektor-electronics.co.uk for a readership poll and other information on ready-made GBDSO cartridge boards with all SMA parts soldered in place.

Project Software

The following software items may be obtained through the Elektor Electronics Readers Services:

EPROM AT27C256, ready-programmed, order code **996528-1**.
Disk, contains DSOGrab utility and MathCad demonstration file, order code **996035-1**.

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